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2000 western Tottori earthquake triggered by latent magmatism: variations in the 3He/4He ratios in the source region

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A magnitude (Mj) 7.3 intraplate earthquake occurred in the western Tottori area, southwest Japan, on 6 October 2000, where there was no apparent prefaulting subsurface indication of the source fault of the 2000 earthquake. Magnetotelluric soundings were taken in and around the aftershocks occurred in order to image three-dimensional electrical resistivity structure at depths of up to 40 km, which could indicate an anomalously conductive body in the middle crust to the upper mantle on the southwest side of the source fault. Free gas and dissolved gases collected from groundwater wells around the seismic source region are characterized by 3He/4He ratios several times higher than the atmospheric value; the highest value of 5.1 RA is similar to those of typical arc-related volcanic gases. Although alkali basalts of early Pleistocene age are sparsely distributed in the western Tottori area, the observed 3He/4He ratios are higher than the calculated 3He/4He ratio derived from the ancient magmatism, considering post-extrusive radiogenic ingrowth of 4He by decay of U and Th included in the magma. Therefore, it is concluded that the geophysical anomaly imaged to the southwest of the source fault is attributed to latent magmatism in the present-day subduction system. Aqueous fluids separated from the cooling crustal magma could cause deep low-frequency earthquakes around the Moho discontinuity and migrate into the brittle upper crust. In addition, the presence of aqueous fluid is expected to weaken the crustal materials. Locally anelastic deformation, implying notable compressive deformation in the E-W direction, was observed in the region where aftershocks were distributed. Under overpressure conditions, the existing fault could serve as a pathway for aqueous fluids expelled from magma with high 3He/4He ratios, so that the upwelling of overpressurized fluids toward the Earth's surface results in the emanation of groundwaters with high 3He/4He ratios along the trace of the source fault segments.

Keywords: 2000 western Tottori earthquake, helium isotope, latent magmatism